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Pavlov's conceptualization of learning

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Introductory texts in psychology create the misleading impression that I. P. Pavlov was concerned solely with conditioned reflexes. In fact, influenced by Woodworth's *Contemporary Schools of Psychology* (1931), Pavlov also became interested in learning. Pavlov proposed a two-factor learning theory according to which all learning was based on association, but conditioning and trial and error learning had specific functions. According to Pavlov, conditioned reflexes were temporary and unstable and therefore more flexible in the interaction of higher organisms with the changing environment. Trial and error learning provided knowledge and was relatively more stable. Scientific discovery was based on facts obtained by trial and error; valid relations were reinforced by experimental results, whereas incorrect relationships were extinguished. Some suggestions are made that would allow authors of introductory texts to describe more informatively the contributions of Pavlov to modern psychology.

A review of 28 introductory texts published in the 1980s reveals that each text links I. P. Pavlov with the classical conditioning paradigm.[1] The text authors invariably present Pavlov's principles of conditioning in the chapter on learning side by side with the contributions of other learning theorists, such as E. L. Thorndike and B. F. Skinner. Readers may thus conclude that contemporary psychologists consider Pavlov an important learning theorist, albeit concerned solely with classical conditioning. This is not strictly true. Pavlov was interested in many areas of traditional psychology, and his interest in learning went beyond the mere consideration of conditioned reflexes (CRs).

Pavlov and his many disciples performed conditioning experiments for almost 4 decades to formulate a theory of higher nervous activity. The aim of this theory was to describe the function of the brain in the interaction of higher animals with the external environment. If the theories of Guthrie (1930) and Hull (1943) are considered models of "learning theories," then Pavlov's theory was also a learning theory.

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However, until the 1930s, Pavlov was unaware that his work on CRs was directly pertinent to a learning theory as envisioned by American psychologists. When Pavlov read that his CR findings were considered by Woodworth (1931) to be a learning theory, he was not convinced that learning could occur solely through classical conditioning.

My argument here is that Pavlov was a learning theorist like his contemporaries Guthrie and Hull. Evidence will be presented that, in the 1930s, Pavlov held that modifications of activity of higher organisms as a consequence of interactions with the external environment were based on the establishment of associations through classical conditioning and trial and error.

Woodworth's Influence on Pavlov

At the October 24, 1934, Wednesday Seminar, a weekly meeting of the Pavlovians, Pavlov referred to having recently received Woodworth's (1931) *Contemporary Schools of Psychology.* Pavlov was impressed by Woodworth's clarity and erudition: "This book belongs to [the category of] exceptional books. It creates the impression that its author throughout the book precisely understands what he is talking or writing about" (Orbeli, 1949a, p. 514).

The book must have sparked Pavlov's interest in "learning theory" as such. During the November 28, 1934, Wednesday Seminar, Pavlov again referred to Woodworth's book. Pavlov stated that he had known of Woodworth for a long time and that he considered him "a person who thinks, and does not have the habit of writing about things he does not understand" (Orbeli, 1949a, p. 561). At the weekly meeting on December 5, 1934, Pavlov stated that Woodworth accepted his conditioned reflex theory as a learning theory, but that Woodworth considered contemporary learning theories to be as uncertain as ever. Indeed, Woodworth (1931, p. 123) wrote that "the theory of learning [is] more uncertain than ever." By this Woodworth meant that the results of learning experiments could not be explained by existing learning theories. Pavlov rejected Woodworth's assertion and proceeded to formulate a learning theory.

During the next 5 years Pavlov often changed his views on learning; he was probably examining and reexamining the evidence to reach the best possible theoretical formulation. Thus, during the Wednesday Seminar on October 24, 1934, he stated that the solution of a problem occurs through the formation of CR by means of trial and error, a one-factor theory. A few weeks later, during the December 5, 1934, Wednesday Seminar, Pavlov thought otherwise, proposing that learn-

ing occurs by both classical conditioning and trial and error, a two-factor theory. Shortly before his death, Pavlov spoke again in favor of the two-factor theory. Pavlov had a somewhat idiosyncratic understanding of the concept of learning, and we should become familiar with it while considering his version of learning theory.

Pavlov's Distinction Between Knowledge and Adaptation

Modern dictionaries define learning as a relatively permanent modification of the organism's activity resulting from its interaction with the environment. However, Pavlov thought that learning (Russian *obuchenie*) was the acquisition of knowledge and the process of scientific discovery, whereas adaptation (Russian *prisposoblenie*) was the higher organism's interaction with the changing environment. It is difficult to determine whether Pavlov thought of adaptation as learning; he probably did because, while describing "learning," he mentioned both conditioning and trial and error (Orbeli, 1949a, p. 581). Therefore, in describing Pavlov's learning theory of the 1930s, I decided to use the term *learning* to include both the acquisition of knowledge and the process of adaptation.

According to Pavlov, knowledge and adaptation had a common foundation—the process of association. Pavlov stated during the seminar on November 13, 1935, that association was a generic concept, whereas CR was a specific concept:

> You see, association—is a generic concept, that is, the union of that which previously was separate, an amalgamation, generalization of two points in a functional relationship, [and] their merger into one association. But the CR—is a specific concept. It is also, of course, a union of points that previously were not united, but this is a particular case of union that has a specific biological significance. In the case of the conditioned reflex, we have stable characteristics of [various] defined objects (food, predator, etc.) that are substituted by temporary signals. This is a specific case of association. (Orbeli, 1949b, p. 262)

Then Pavlov outlined another kind of association that had a special meaning to him as a scientist concerned with formulating causal relations between two or more events:

> There is also another case in which phenomena are connected because they impinge simultaneously on the nervous system. In such a case the two phenomena are connected, because they are intrinsically connected in reality. This is another special case of association as it constitutes the foundation of our knowledge, the foundation of the scientific principle of causation. (Orbeli, 1949b, p. 262)

Then, apparently referring to experiments on the acquisition of nonsense syllable lists, Pavlov stated:

> Finally, there is the simple case (one can call it: artificial, occasional, not intrinsic, unimportant) when, for example, two sounds are psychologically connected that in themselves have nothing in common yet do connect because one is repeated after another, and these, finally, get connected so that one can evoke the other. (Orbeli, 1949b, p. 262)

Pavlov's Three Learning Paradigms

Pavlov (1949c) insisted that a scientific theory must be based on facts. To formulate a learning theory, Pavlov used experimental findings. Let us consider the three paradigmatic experiments relevant to his theory of learning, as well as their strengths and limitations: (a) the conditioned reflex, (b) "chaotic reaction" or trial and error experiments, and (c) in Pavlov's words, experiments on "association of associations."

Conditioned reflexes as the processes of adaptation

The systematic study of CRs emerged serendipitously from Pavlov's research on the function of the digestive system. In 1897, the physician Vul'fson, working under Pavlov's direction in the Physiology Department of the Imperial Institute of Experimental Medicine in St. Petersburg, noticed that the amount of salivary secretion depends on the nature of food. Dogs secreted less saliva when they ate moist food than when they ate dry food. Furthermore, the sight of food alone evoked salivation, but in correspondingly smaller amounts. From 1901 on, the Pavlovians abandoned research on the digestive system to devote themselves to the systematic study of the new phenomenon.

Modern introductory texts in psychology usually describe the conditioned stimulus (CS) as different from the unconditioned stimulus (UCS); that is, salivation (CR) is the response to sounds or lights (CS) but not to food. Such descriptions contrast with Vul'fson's procedure in which the CS and the UCS referred to the same stimulus object—food; in the original experiment the CS was food presented at a distance. The CR paradigm described in the introductory texts was discovered by Pavlov's disciple, Boldyrev. Boldyrev (1905) found that an indifferent stimulus, such as a sound produced by a bell or the odor of camphor, if paired repeatedly with feeding, subsequently, when presented alone, evoked a CR (salivation). Pavlov concluded that a response to objects presented at a distance and a response to stimuli coming in contact with the organism's receptors were special cases of conditioning.

During the first decade of research on CRs, Pavlov formulated the conditioning principles that are now *de rigueur* in introductory psychology texts. In 1903, Pavlov's coworker Tolotschinoff reported that after a dog salivated to foods presented at a distance, repeated presentations of foods without subsequent feeding leads to a successive decrease of salivary secretion. Babkin (1904) performed a series of experiments that further clarified the concept of extinction, and Kashereninova (1908) discovered generalization and differentiation. Pavlov explained the newly found principles in terms of hypothesized processes in the cortex, that is, irradiation and concentration of neural excitation and inhibition.

As early as 1903, Pavlov (1949a) proposed, under the influence of Darwin's evolution theory, that reflexes were adaptive processes that helped organisms survive in the environment. Pavlov later described a variety of innate unconditioned reflexes. Pavlov considered complex conditioned reflexes—the alimentary, defensive, freedom, orienting-investigative, sexual, and social—as instincts (cf. Windholz, 1987b). In 1924, Pavlov (1951b, p. 23) stated that "reflexes are merely elements of continuous adaptation and equilibrium [with the environment]." However, were the animal to respond to the environment with unconditioned reflexes only, its survival would be marginal at best. Thus, in a 1924 lecture, Pavlov described the behavior of a decorticated dog that functioned only on the level of unconditioned reflexes (UCRs):

> [The dog] moves toward food and stays away from destructive stimuli. The investigatory reflex functions well; [the dog] reacts to sound by raising the ears and head. The reflex of freedom functions too: [the dog] strongly resists attempts to be grabbed. However, [the dog] is an invalid; it cannot function if left to its own devices. In the present nervous activity, something important is missing. What is it? (1951b, p. 28)

What was missing was the acquired ability to perceive life-sustaining or dangerous conditions from far away and to react to such stimuli in a flexible manner. Whereas the UCRs were susceptible only to the direct stimulation of receptors, the CRs functioned in response to signals that occur in conjunction with the UCSs. The CRs were established by the association of conditioned and unconditioned stimuli (Orbeli, 1949a). The higher organism's reaction to signals emanating from the object or situation obviated the direct contact with these aspects of the environment. The CSs either invited or warned from afar, in both cases increasing the probability of survival.

Unlike UCRs that are set genetically and therefore firmly fixed,

CRs are temporary and unstable, being easily established and as easily terminated (Orbeli, 1949a, p. 581). Pavlov considered the CR to be sensitive to environmental conditions, enhancing the chances for the organism's survival. The CS is a signal for either the approach or the avoidance of environmental objects or events. If an organism's approach or avoidance activity driven by instincts is rewarded, the organism approaches or avoids the same or similar objects or events. Conversely, if an organism's activity is not rewarded, the previously established approach and avoidance tendencies are extinguished. In short, the CRs were, as Pavlov (1949a, p. 141) stated in 1903, "the fact of improved adaptation."

The trial and error paradigm for acquiring knowledge

Pavlov (1951c) was fully aware of Thorndike's trial and error learning and even ventured to guess that Thorndike's work preceded his own. In the 1930s, Pavlov asserted that Thorndike's experiments contributed to the understanding of problem solutions:

> Of great, fundamental importance was the first systematic investigation by Thorndike involving the opening of boxes by animals. The animals were locked in the boxes and they strove to get out either to gain freedom or to get food that was outside. The animals performed a lot of movements which finally led to the opening of the door. The specific movement that led to the attainment of the goal was with successive trials more and more rapidly and precisely performed. This means, evidently, that knowledge of the relation among the material objects in the environment was acquired, and with that knowledge the mastery over these [objects]. (1975, p. 101)

During the Wednesday Seminar of December 5, 1934, Pavlov (Orbeli, 1949a) explained trial and error learning in the following way: Fundamental to learning are instincts that prompt the organism to action. Instincts, such as hunger or the quest for freedom, are innately determined. The operation of instinct is tantamount to the neural excitation in the brain. The neural excitation is the basis for the formation of associations. Initially, in the learning process, associations are poorly developed but become more extensive with the organism's increased interaction with the environment. Pavlov explained that in Thorndike's experiment, perhaps the cat was attracted to food located outside the cage and performed a variety of movements until a specific, maybe a chance, movement impinged on the bolt opening the door to freedom. The cat, as a result, associated the physical pressure on the bolt with freedom and feeding. The satiated animal may in the future apply pressure on the same bolt when seeking freedom instead of food. The gist of Thorndikian trial and error learning was the

formation of an association between the kinesthetic action and an object or a condition.

Unlike associations acquired through the method of CRs, associations formed through trial and error were relatively stable or long lasting. Such association was equivalent to thinking, reasoning, and understanding. The relative stability of scientific knowledge is a consequence of trial and error. Scientific knowledge may have started as the result of an accidental association between an action and its consequences. Therefore, in its initial stage, scientific knowledge may be superficial, but subsequent use of trial and error is apt to eliminate false associations so that only dependable knowledge remains.

After the presentation of the conditioned reflex and the trial and error paradigms, Pavlov said that he was grateful for Woodworth's book, which challenged his views on learning, made him think about the problem of learning, and led him to address it properly (Orbeli, 1949a).

The "association of associations" experiments

From 1931 to 1934, Pavlov's disciples Narbutovich and Podkopaev (1936) tested Pavlov's 1924 assertion that although the CR is established when an indifferent stimulus precedes the unconditioned stimulus, such an arrangement was not the only possible cause of a merger of the centers of neural excitation in the cortex. If two centers of cortical excitation are evoked one after the other by different stimuli, the excitations of the centers will merge. In their experiment, a harnessed dog was placed between a light and a sound source. The sound stimulus was presented for 5 s and was immediately followed by the light for 5 s. As soon as the stimulus was produced, the dogs paid attention to it by turning the head in that direction—the orienting reflex. After the stimulus pairs were repeated 30 times, the light stimulus was followed by feeding. As a result, a CR between the light stimulus and the salivary response was established. Subsequently, the sound stimulus was produced alone and the dog salivated immediately. As the CR was initially established in response to the light, the immediate salivation to sound demonstrated that during the initial part of the experiment an association between light and sound stimuli was established.

Pavlov called this phenomenon "association of associations," presumably because it was a novel association (a) between the sound and light stimuli or (b) between either of the two stimuli with the conditioned stimulus that triggered the CR. The latter should not be surprising because, according to Pavlov, the CR was an S-S and not an S-R association.

CONCLUSIONS AND REFLECTIONS

We have seen that Pavlov considered the acquisition of learning as a formation of connections among cortical centers on the physiological level and the formation of association on the psychological level. It was a two-factor theory because adaptation to the external environment occurs by the formation of CRs which are temporary and unstable, whereas the acquisition of relatively stable knowledge is obtained by trial and error, which involves kinesthetic impact on an environmental entity to achieve a desired result. The process of extinction can be inferred from this theory: For CRs, extraneous stimuli and unrewarded responses evoke in the cortex an irradiation of inhibition that counteracts the previously established excitatory processes, or in psychological terms, the dissolution of association. Knowledge acquired by trial and error becomes disturbed by nonreinforcement, wherein an irradiation of inhibitory processes is invoked in the cortex. Generalization and differentiation in CRs also may be inferred from the theory in terms of complex relations of irradiation and concentration of cortical excitation and inhibition. The same principles possibly apply to knowledge acquired by trial and error.

Authors of introductory psychology textbooks who associate classical conditioning with Pavlov invariably use as their source G. V. Anrep's translation of Pavlov's lectures held in 1924, titled *Conditioned Reflexes* (1927). The massive array of experiments presented by Pavlov in a simple but authoritative manner may create a strong impression on readers apparently unaware that Pavlov had in the 1930s modified his theory. Moreover, it is possible that readers may unconsciously understand Pavlov's conceptualization of learning from the behavioristic perspective.

The influence of Watson, Guthrie, and Skinner is discernible in the presentation of Pavlov's work in introductory texts. Skinner's (1938) division of learning in terms of respondent and operant conditioning may be reflected in the separation of the CR and the trial and error paradigms found in introductory texts. The description of Pavlov's conceptualization of behavior in terms of Cartesian, mechanistic reflexes bears the traces of Guthrie's (1930) conditioning theory that considered complex behavior as an accumulation of stimulus-response associations. Guthrie's molecular theory clashes with Pavlov's molar theory in which association is viewed as the total amalgamation of the constituting associations that emerge as an idea. The presentation of CRs without reference to conscious experience suggests Watson's (1930) *Weltanschaung,* which dispenses with the need to consider subjective

experiences. Pavlov (1951a), using the objective method with nonhuman subjects, avoided the consideration of subjective, conscious experience mainly out of fear of anthropomorphizing. But this should not be taken to mean that Pavlov disregarded conscious experience. In particular, Pavlov in 1933 expressed the hope that soon a time would come when a merger between psychological, conscious experience, and physiological processes would be realized (Pavlov, 1949b).

Introductory psychology texts are written to acquaint the student with psychologists' conceptualizations of their discipline. A number of studies show that modern American psychologists consider the work of Pavlov a significant contribution to their field (cf. Windholz, 1987a). The description of Pavlov in introductory texts may take a number of approaches. It is possible to stress Pavlov's humanity; he was an imaginative scientist devoted to his work and respected by his numerous students despite his occasional outbursts of ire (cf. Windholz, 1990). Or, it is possible to emphasize Pavlov's contributions to psychology. If the author chooses to describe the Pavlovian discovery of CRs, then, to reflect the historical events, it becomes necessary to stress the paradigmatic nature of salivary conditioned reflex experiments. Authors should emphasize that Pavlov (1949a, p. 136) maintained that the salivary reflex had a "physiologically insignificant role" and then describe the conditioning of the more important unconditioned reflexes, or instincts, that are described by Pavlov (1927), stressing their function in the higher organism's adaptation to the continuously changing external environment.

Notes

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1. A list of these 28 texts in introductory psychology will be provided on request.

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